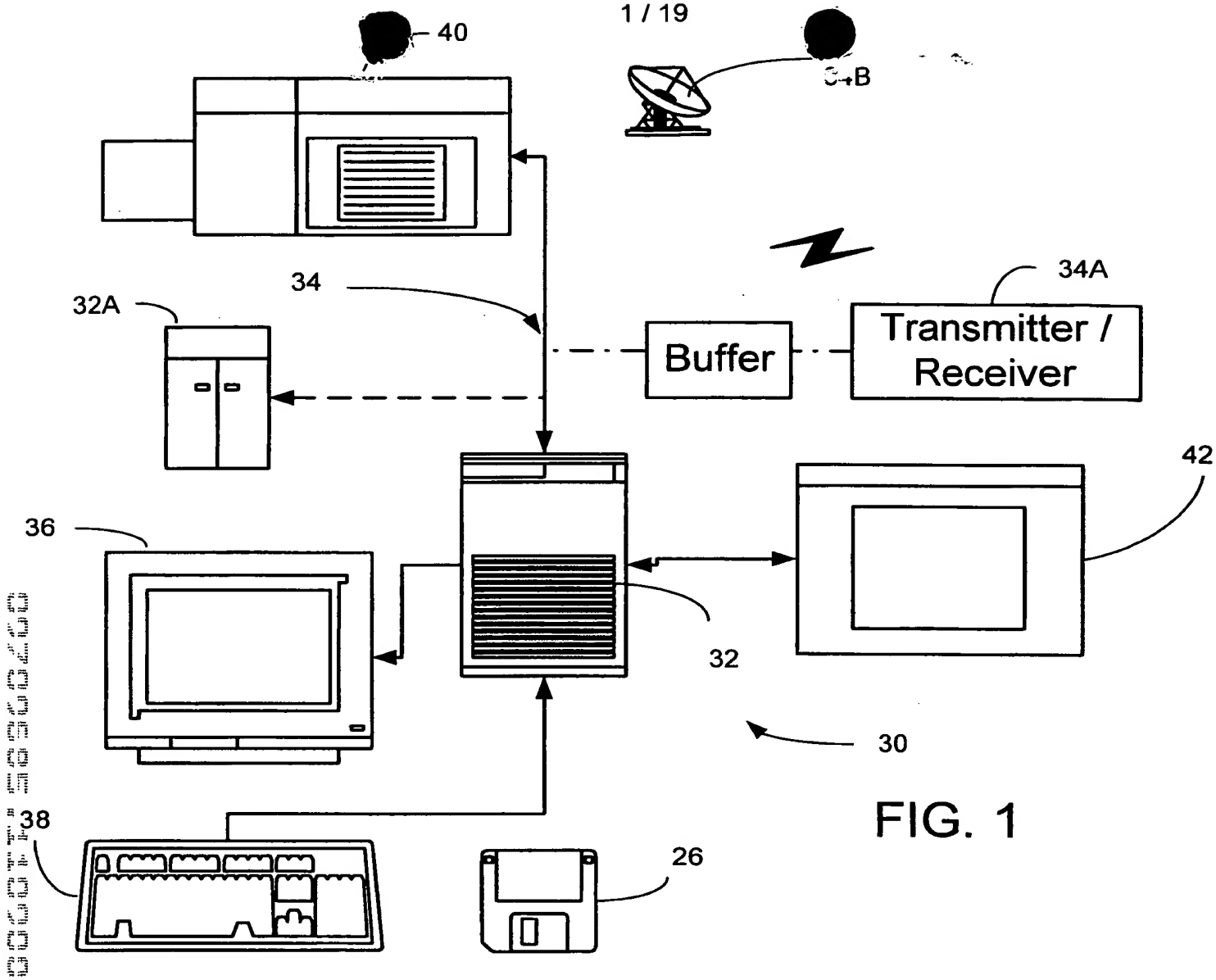

40
34B
34
34A
32A
Buffer
Transmitter / Receiver
42
36
32
30
38
26

FIG. 1

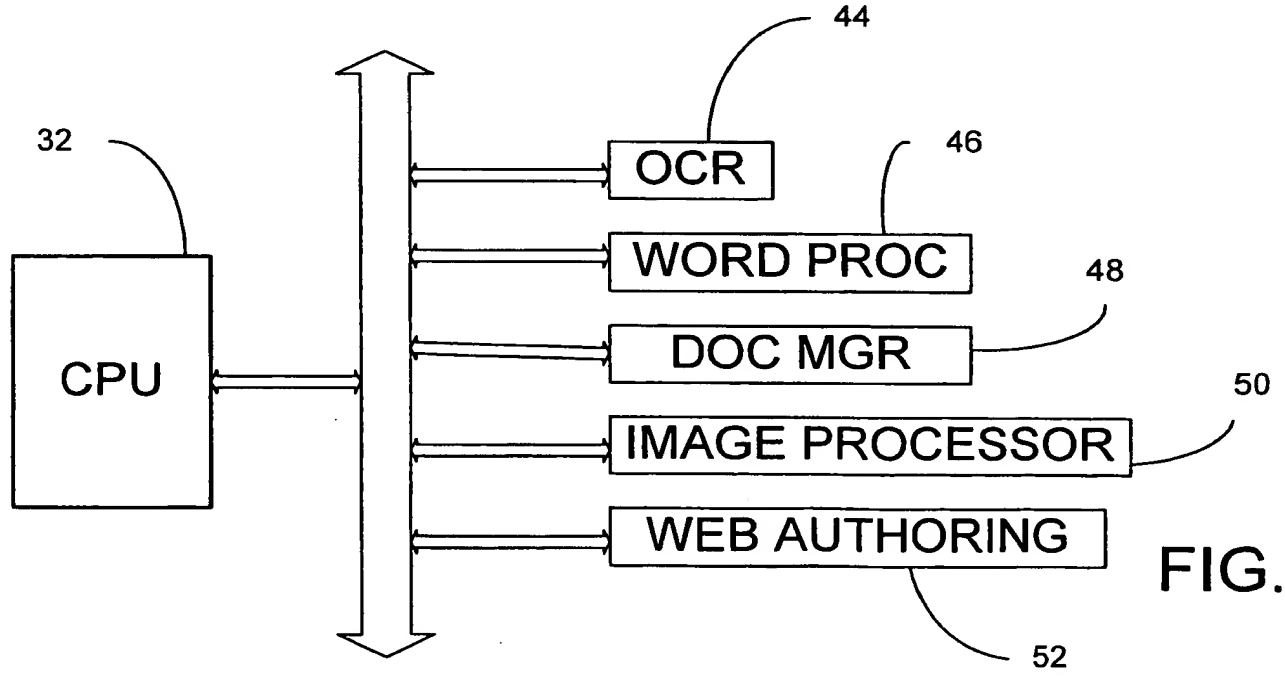
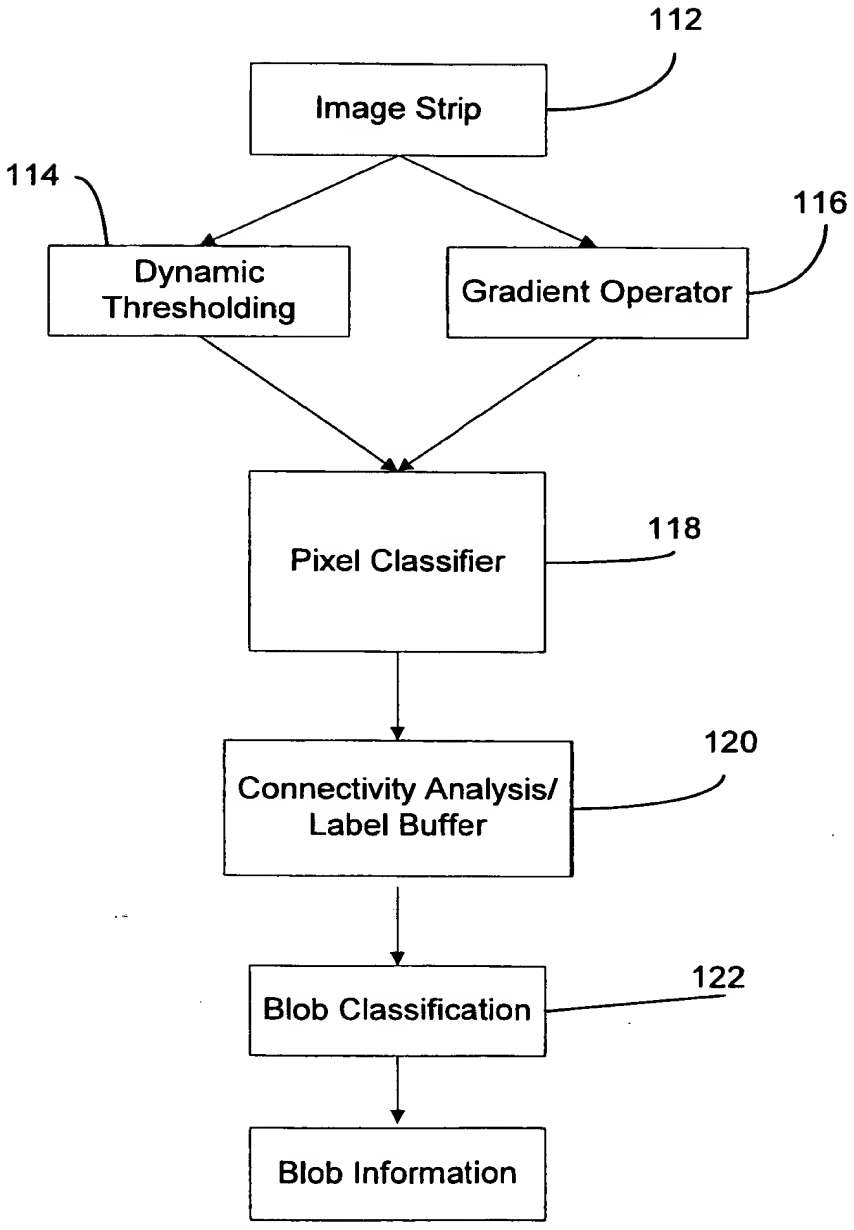

44
32
OCR
46
WORD PROC
48
CPU
DOC MGR
50
IMAGE PROCESSOR
WEB AUTHORING
52

FIG. 2

FIG. 3


112
Image Strip
114
116
Dynamic Thresholding
Gradient Operator
Pixel Classifier
118
120
Connectivity Analysis/ Label Buffer
122
Blob Classification
Blob Information

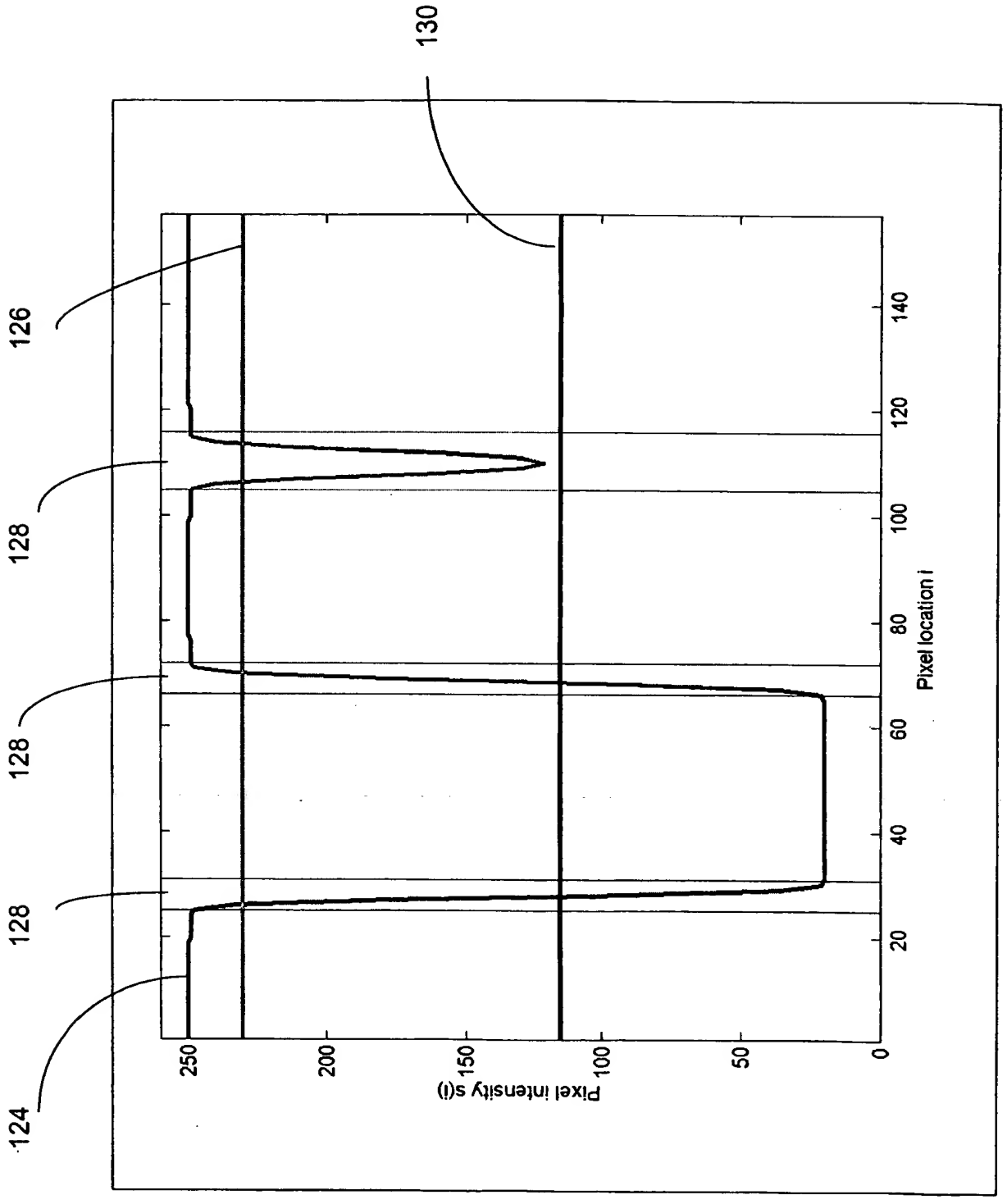

130
126
128
128
128
124
Pixel intensity s(i)
250
200
150
100
50
0
20
40
60
80
100
120
140
Pixel location i

FIG. 4

FIG. 5

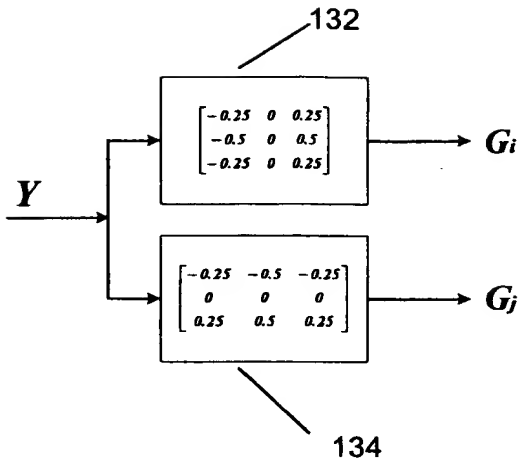


FIG. 6

$$C(Y, \|\nabla Y\|, Chroma) = \begin{cases} \text{WHITE}, & chroma < T_c \text{ AND } \|\nabla Y\| < T_e \text{ AND } Y \geq T_w \\ \text{WHITE EDGE}, & chroma < T_c \text{ AND } \|\nabla Y\| \geq T_e \text{ AND } Y \geq T_w \\ \text{GRAY}, & chroma < T_c \text{ AND } \|\nabla Y\| < T_e \text{ AND } T_g \leq Y < T_w \\ \text{GRAY EDGE}, & chroma < T_c \text{ AND } \|\nabla Y\| \geq T_e \text{ AND } T_g \leq Y < T_w \\ \text{BLACK}, & (chroma < T_c \text{ AND } Y < T_g) \text{ OR } Y \leq 30 \\ \text{COLOR}, & chroma \geq T_c \text{ AND } \|\nabla Y\| < T_e \\ \text{COLOR EDGE}, & chroma \geq T_c \text{ AND } \|\nabla Y\| \geq T_e \end{cases}$$

(Equation 2.)

FIG. 7

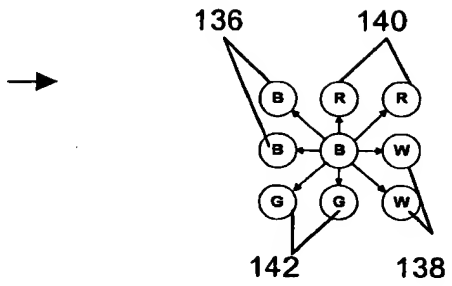


FIG. 8

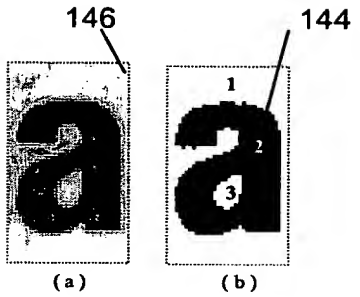


FIG. 9

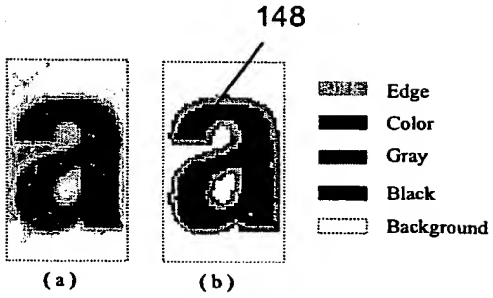


FIG. 10

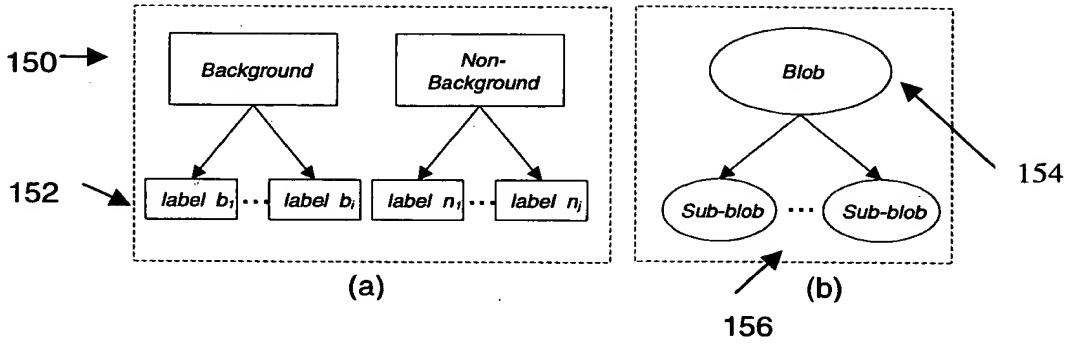

150
Background
Non-Background
152
label b_1
label b_i
label n_1
label n_j
(a)
Blob
Sub-blob
Sub-blob
154
156
(b)

FIG. 11

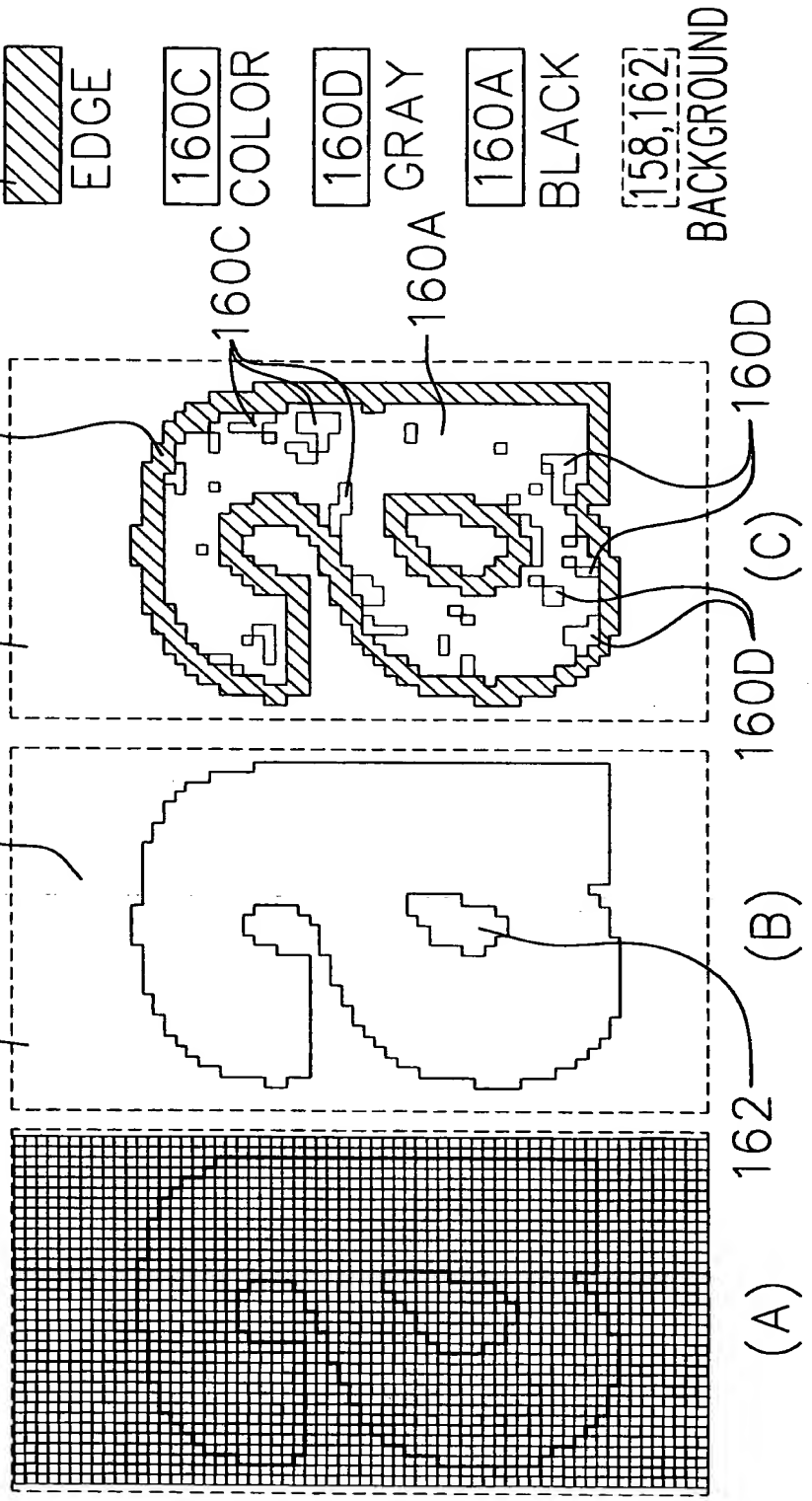

160B
EDGE
160C
COLOR
160D
GRAY
160A
BLACK
158,162
BACKGROUND
160B
160C
160A
160D
158
160
158
160D
162
(A)
(B)
(C)

FIG. 12

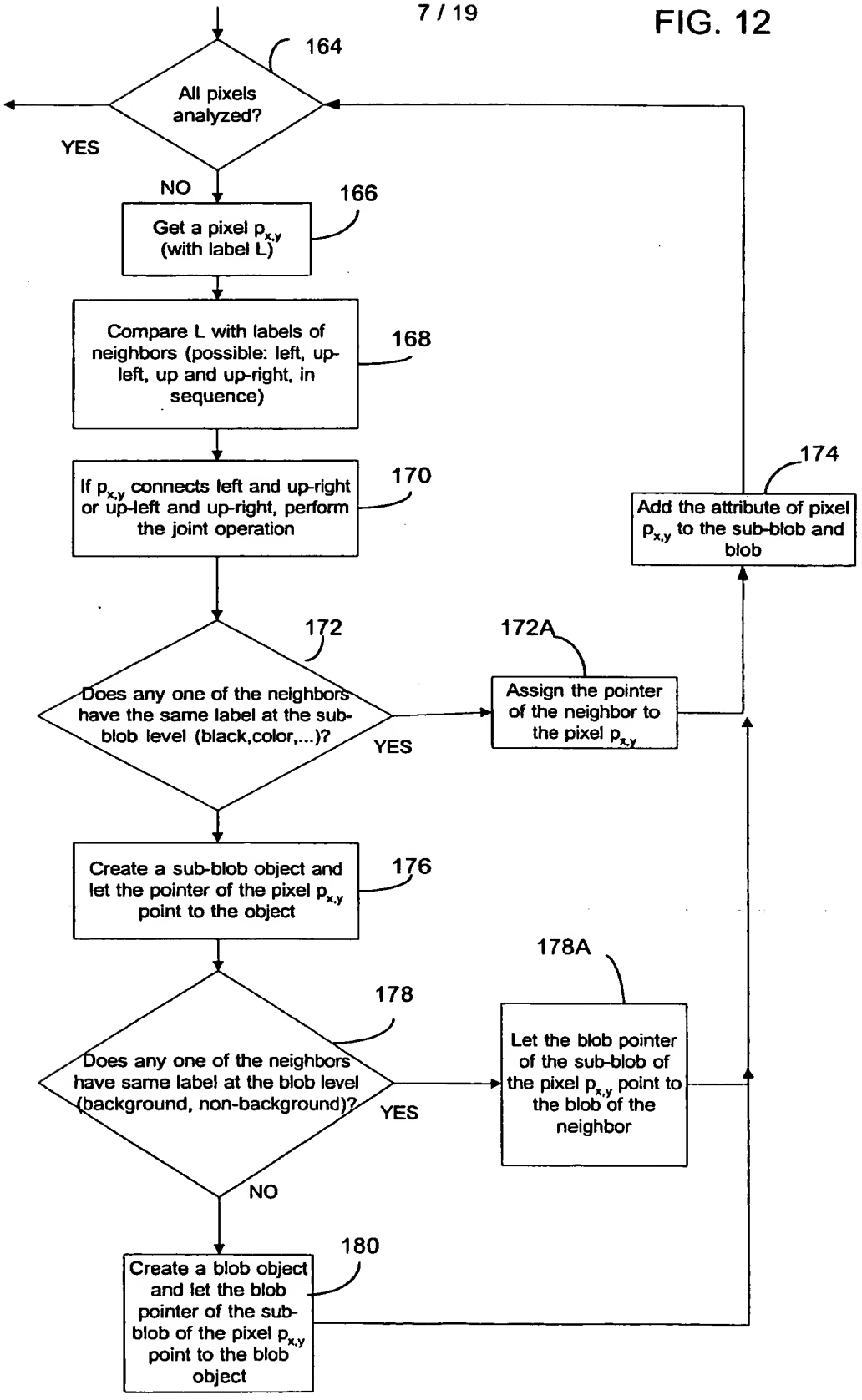

164
All pixels analyzed?
YES
NO
166
Get a pixel $p_{x,y}$ (with label L)
168
Compare L with labels of neighbors (possible: left, up-left, up and up-right, in sequence)
170
If $p_{x,y}$ connects left and up-right or up-left and up-right, perform the joint operation
172
Does any one of the neighbors have the same label at the sub-blob level (black,color,...)?
YES
172A
Assign the pointer of the neighbor to the pixel $p_{x,y}$
174
Add the attribute of pixel $p_{x,y}$ to the sub-blob and blob
176
Create a sub-blob object and let the pointer of the pixel $p_{x,y}$ point to the object
178
Does any one of the neighbors have same label at the blob level (background, non-background)?
YES
178A
Let the blob pointer of the sub-blob of the pixel $p_{x,y}$ point to the blob of the neighbor
NO
180
Create a blob object and let the blob pointer of the sub-blob of the pixel $p_{x,y}$ point to the blob object

FIG. 12A

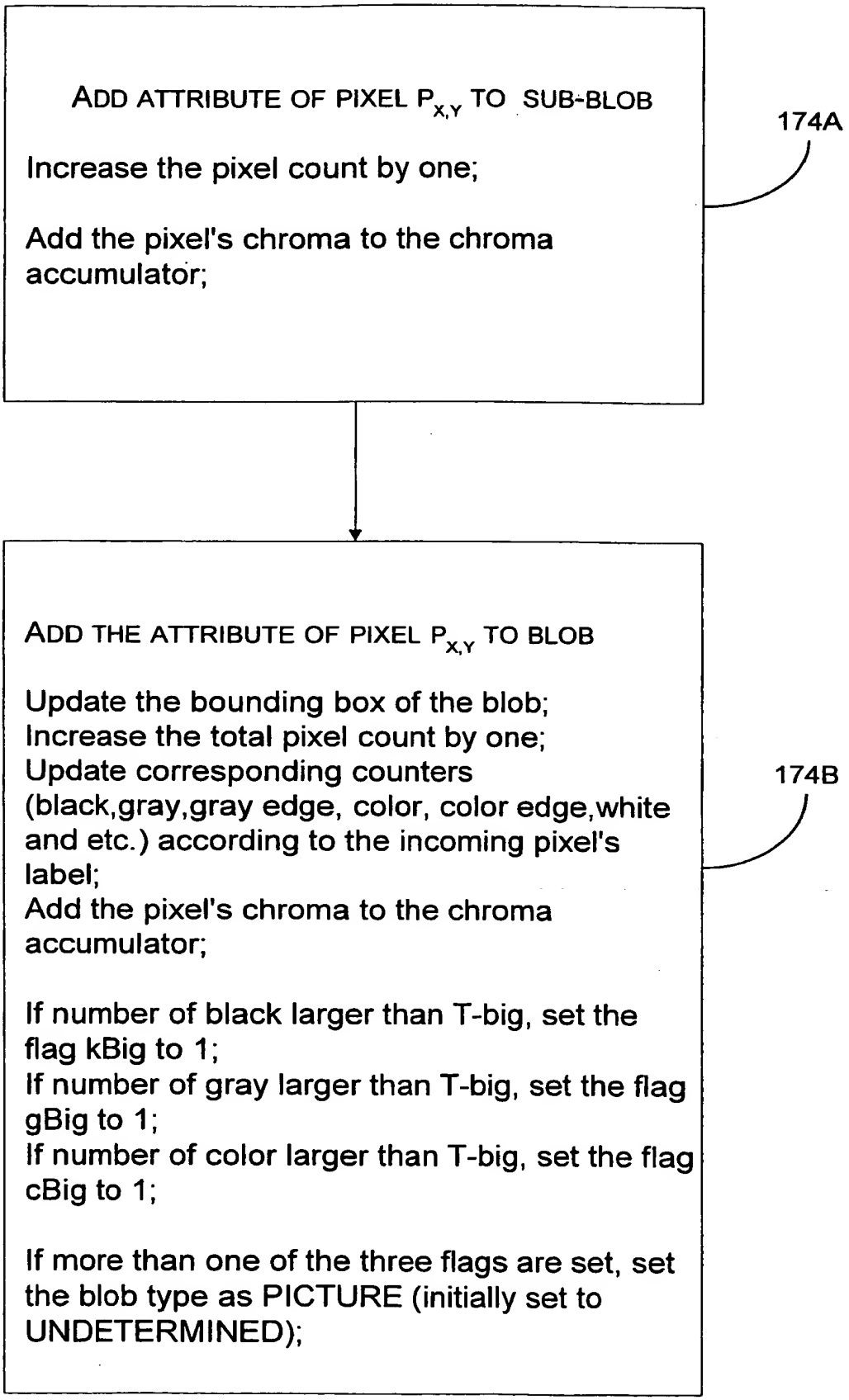

ADD ATTRIBUTE OF PIXEL $P_{X,Y}$ TO SUB-BLOB
Increase the pixel count by one;
Add the pixel's chroma to the chroma accumulator;
174A
ADD THE ATTRIBUTE OF PIXEL $P_{X,Y}$ TO BLOB
Update the bounding box of the blob;
Increase the total pixel count by one;
Update corresponding counters (black,gray,gray edge, color, color edge,white and etc.) according to the incoming pixel's label;
Add the pixel's chroma to the chroma accumulator;
If number of black larger than T-big, set the flag kBig to 1;
If number of gray larger than T-big, set the flag gBig to 1;
If number of color larger than T-big, set the flag cBig to 1;
If more than one of the three flags are set, set the blob type as PICTURE (initially set to UNDETERMINED);
174B

FIG. 13

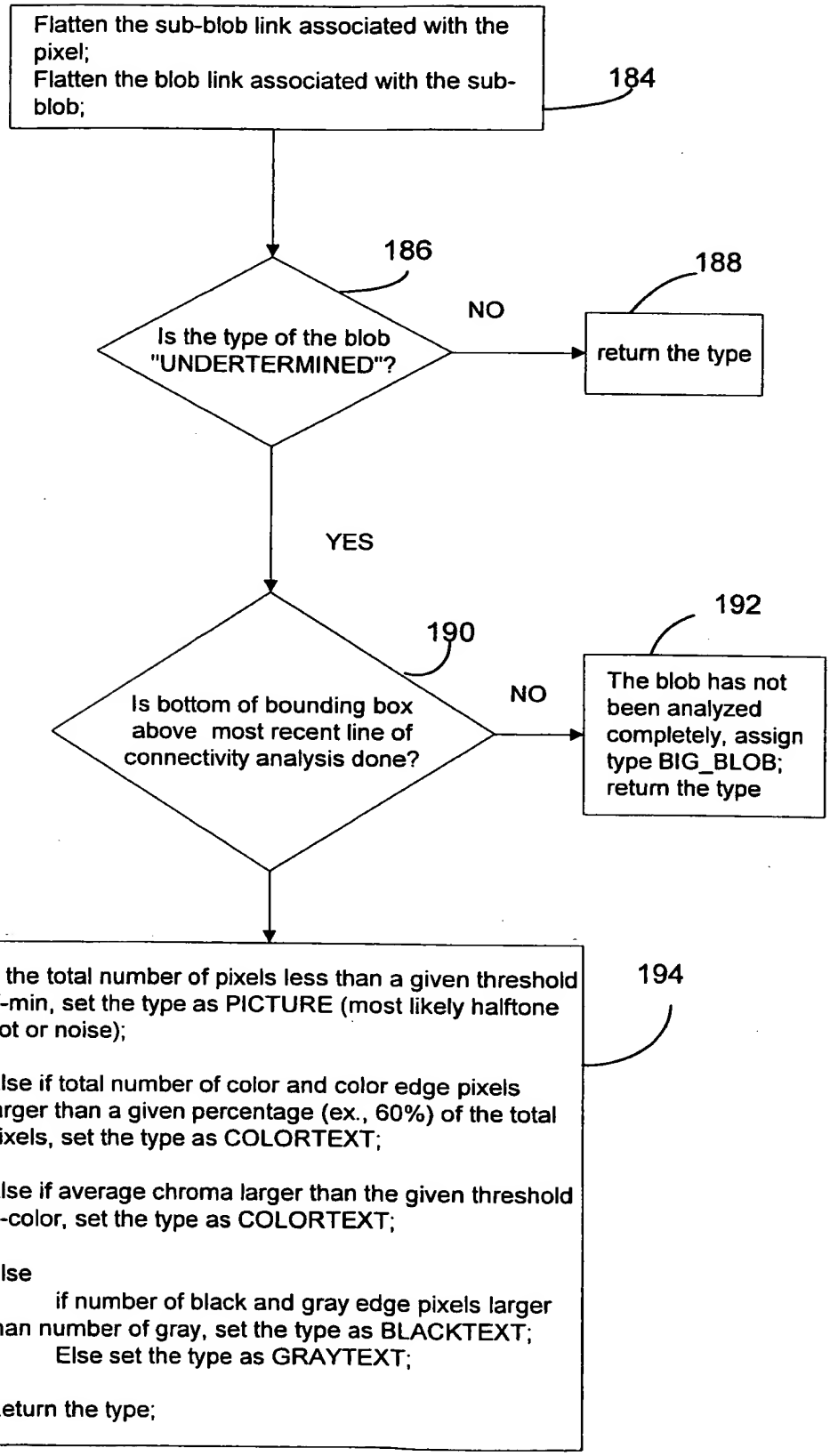

Flatten the sub-blob link associated with the pixel;
Flatten the blob link associated with the sub-blob;
184
186
Is the type of the blob "UNDERTERMINED"?
NO
188
return the type
YES
190
Is bottom of bounding box above most recent line of connectivity analysis done?
NO
192
The blob has not been analyzed completely, assign type BIG_BLOB; return the type
194
If the total number of pixels less than a given threshold T-min, set the type as PICTURE (most likely halftone dot or noise);
Else if total number of color and color edge pixels larger than a given percentage (ex., 60%) of the total pixels, set the type as COLORTEXT;
Else if average chroma larger than the given threshold T-color, set the type as COLORTEXT;
Else
if number of black and gray edge pixels larger than number of gray, set the type as BLACKTEXT;
Else set the type as GRAYTEXT;
Return the type;

FIG. 14

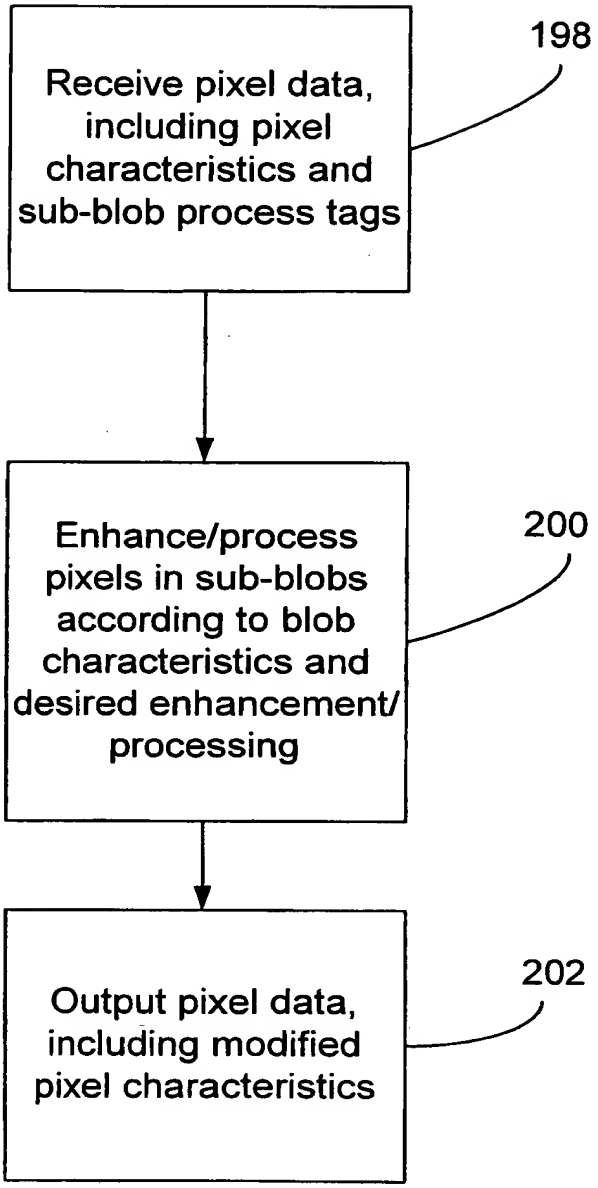

Receive pixel data, including pixel characteristics and sub-blob process tags
198
Enhance/process pixels in sub-blobs according to blob characteristics and desired enhancement/ processing
200
Output pixel data, including modified pixel characteristics
202

FIG. 15

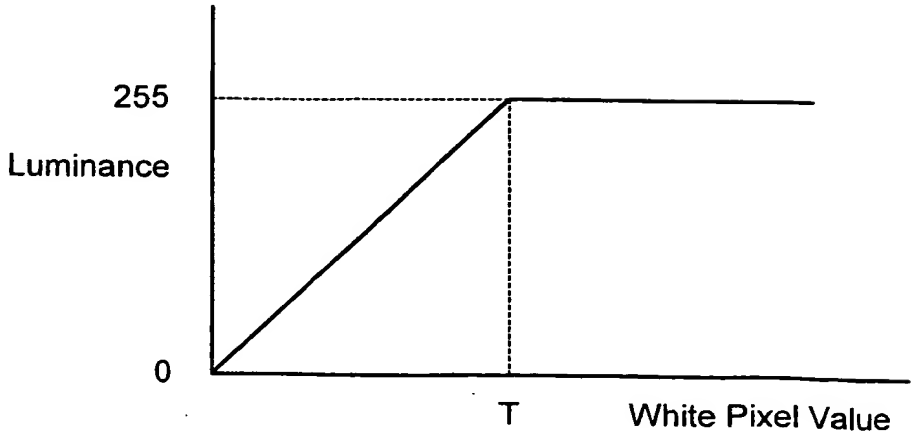

255
Luminance
0
T
White Pixel Value

FIG. 16

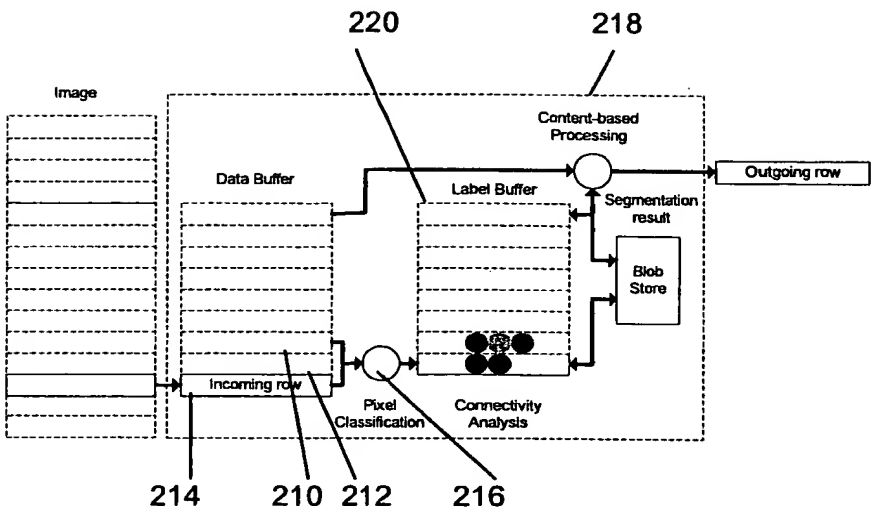

220
218
Image
Content-based Processing
Data Buffer
Label Buffer
Outgoing row
Segmentation result
Blob Store
Incoming row
Pixel Classification
Connectivity Analysis
214
210
212
216

FIG. 17

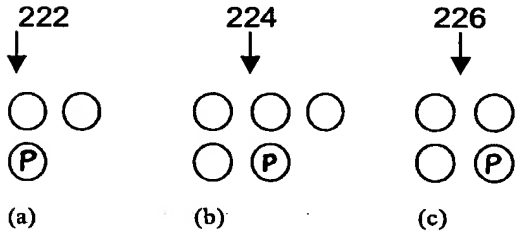

222
224
226
P
P
P
(a)
(b)
(c)

FIG. 18

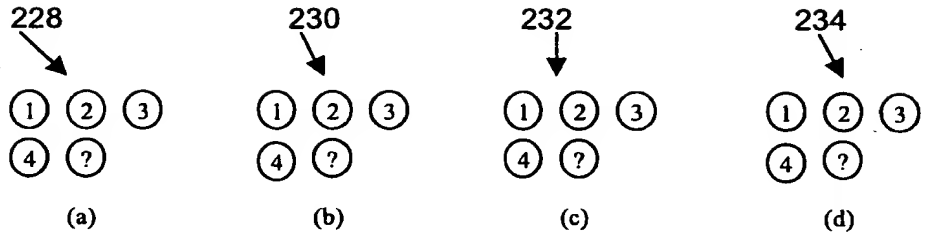


FIG. 20

238

Box 1. Pseudo-code for the joint operation.

```
Joint ( SubBlob *pSB1, SubBlob *pSB2)

1. Trace pSB1 to the root rtSB1;
2. Trace pSB2 to the root rtSB2;
3. Combine the two root nodes by adding
   attribute of rtSB2 to rtSB1 and in turn
   joining (works the same fashion as this
   one) two blobs if necessary;
4. Delete SBCore associated with rtSB2;
5. Link rtSB2 to rtSB1;
```

FIG. 21

Box 2. Pseudo-code for the flatten operation.

240

Flatten (SubBlob *pSB)

1. Trace pSB to the root rtSB while short-cutting the nodes with only one reference count (for example in A=>B=>C, B is only pointed by A. In this case A can be pointed directly to C bypassing B)
2. Start from pSB again and point all link pointers directly to the root node rtSB

FIG. 19

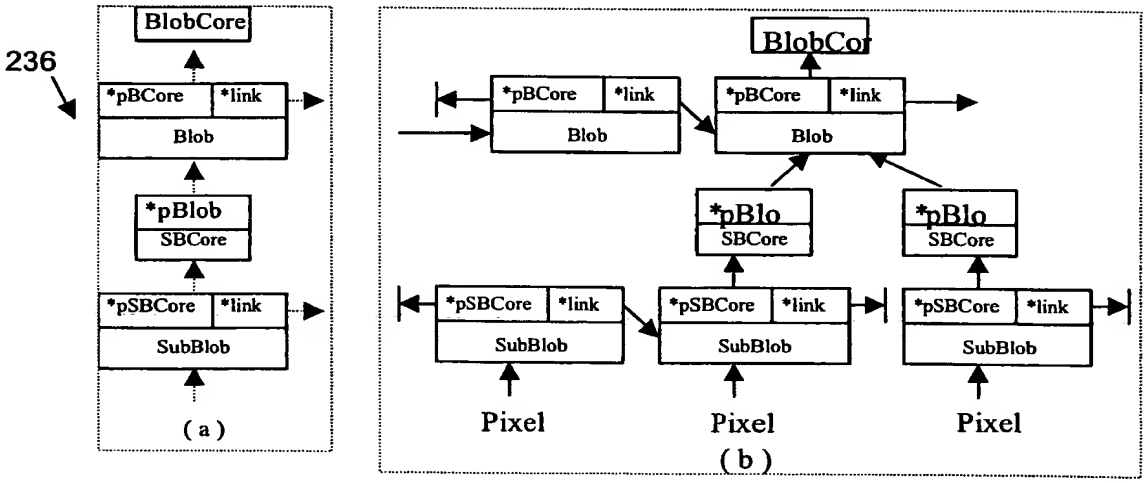


FIG. 22

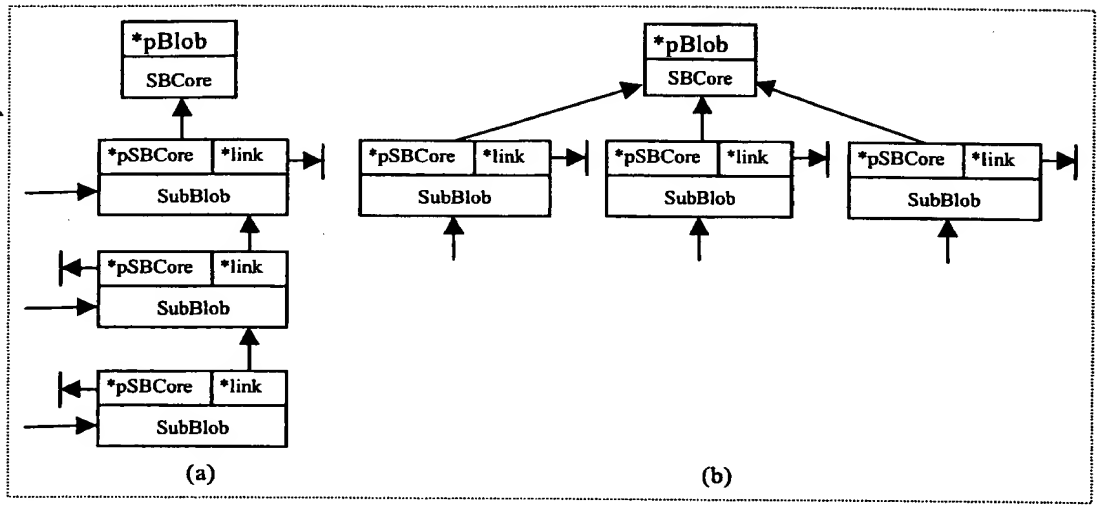

242
*pBlob
SBCore
*pSBCore
*link
SubBlob
*pSBCore
*link
SubBlob
*pSBCore
*link
SubBlob
(a)
*pBlob
SBCore
*pSBCore
*link
SubBlob
*pSBCore
*link
SubBlob
*pSBCore
*link
SubBlob
(b)

FIG. 23

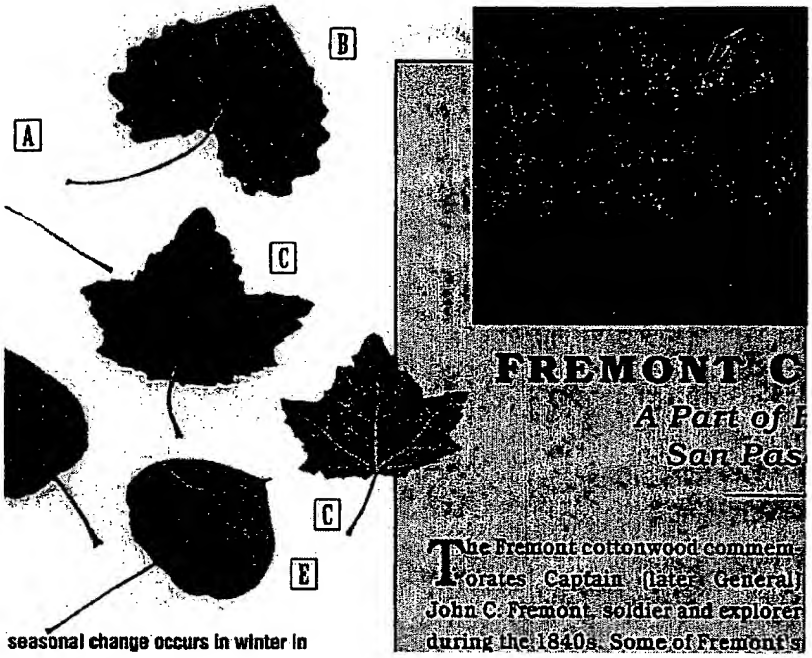

A
B
C
C
E
seasonal change occurs in winter in
FREMONT C
A Part of
San Pas
The Fremont cottonwood commem-
orates Captain (later General)
John C. Fremont, soldier and explorer
during the 1840s. Some of Fremont's

FIG. 24

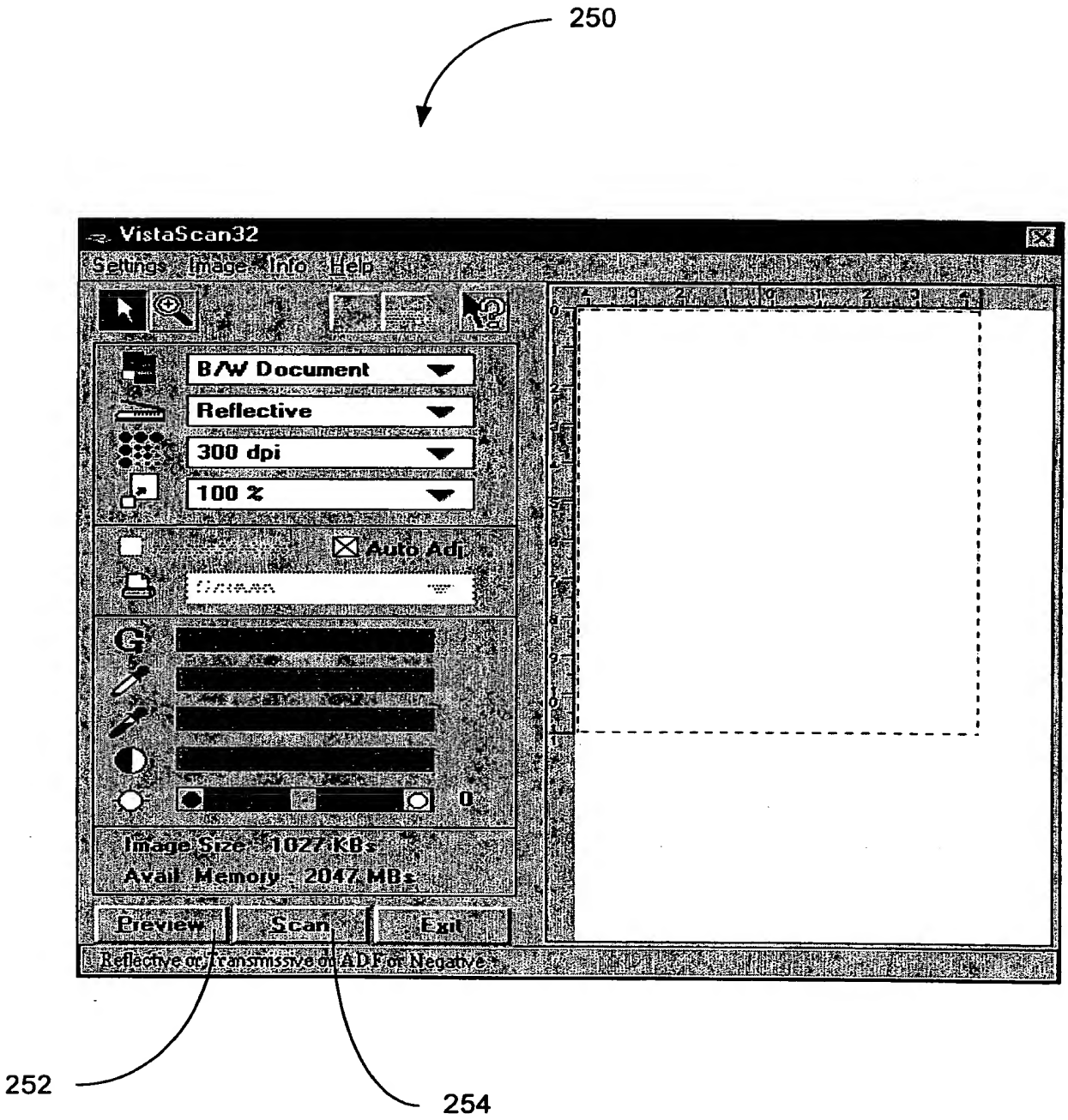

250
VistaScan32
Settings
Image
Info
Help
B/W Document
Reflective
300 dpi
100 %
Auto Adj
Image Size: 1027 KBs
Avail Memory: 2047 MBs
Preview
Scan
Exit
Reflective or Transmissive or ADF or Negative
252
254

FIG. 25

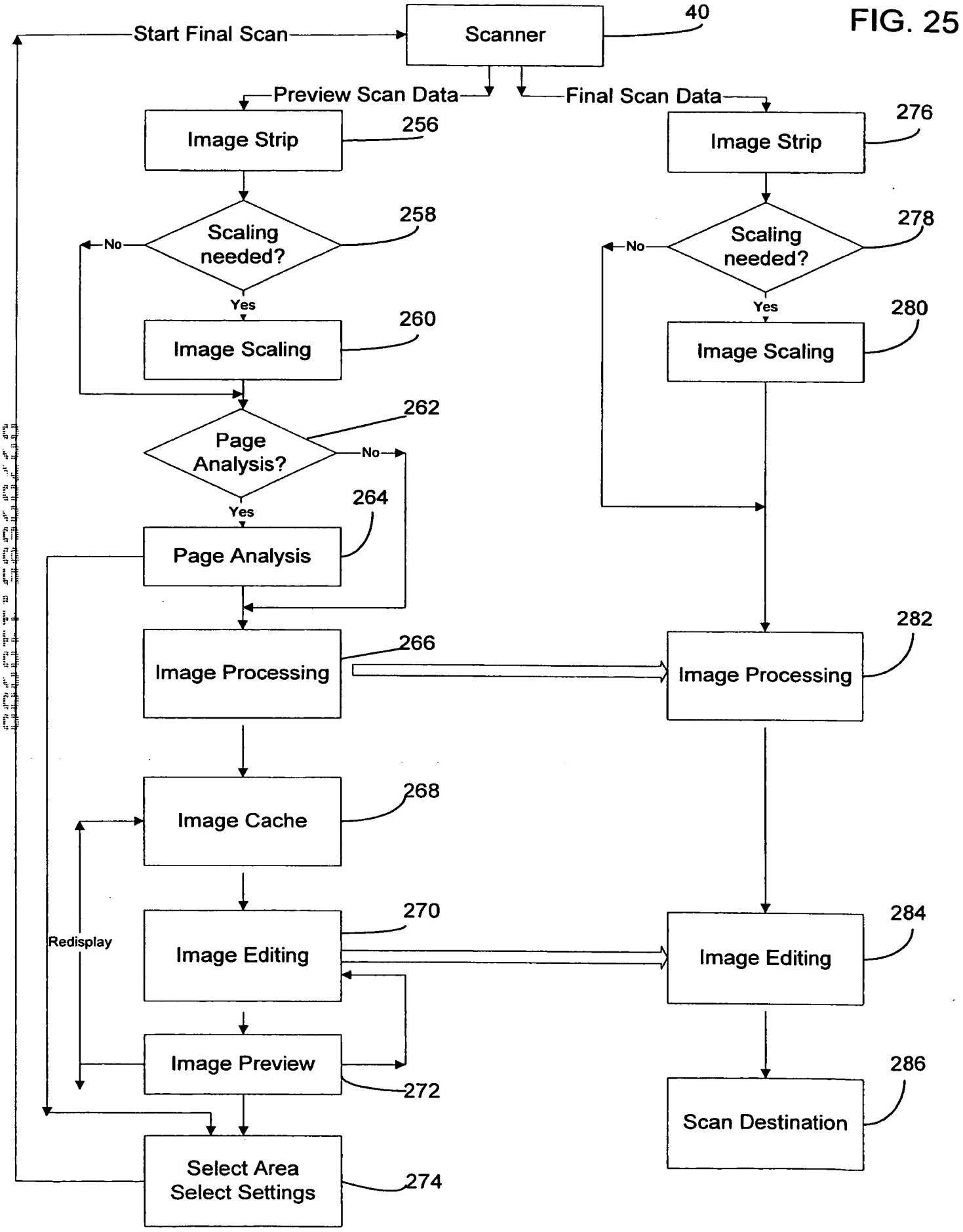

Start Final Scan
Scanner
40
Preview Scan Data
Final Scan Data
Image Strip
256
Image Strip
276
Scaling needed?
258
No
Yes
Scaling needed?
278
No
Yes
Image Scaling
260
Image Scaling
280
Page Analysis?
262
No
Yes
Page Analysis
264
Image Processing
266
Image Processing
282
Image Cache
268
Redisplay
Image Editing
270
Image Editing
284
Image Preview
272
Scan Destination
286
Select Area
Select Settings
274

FIG. 26

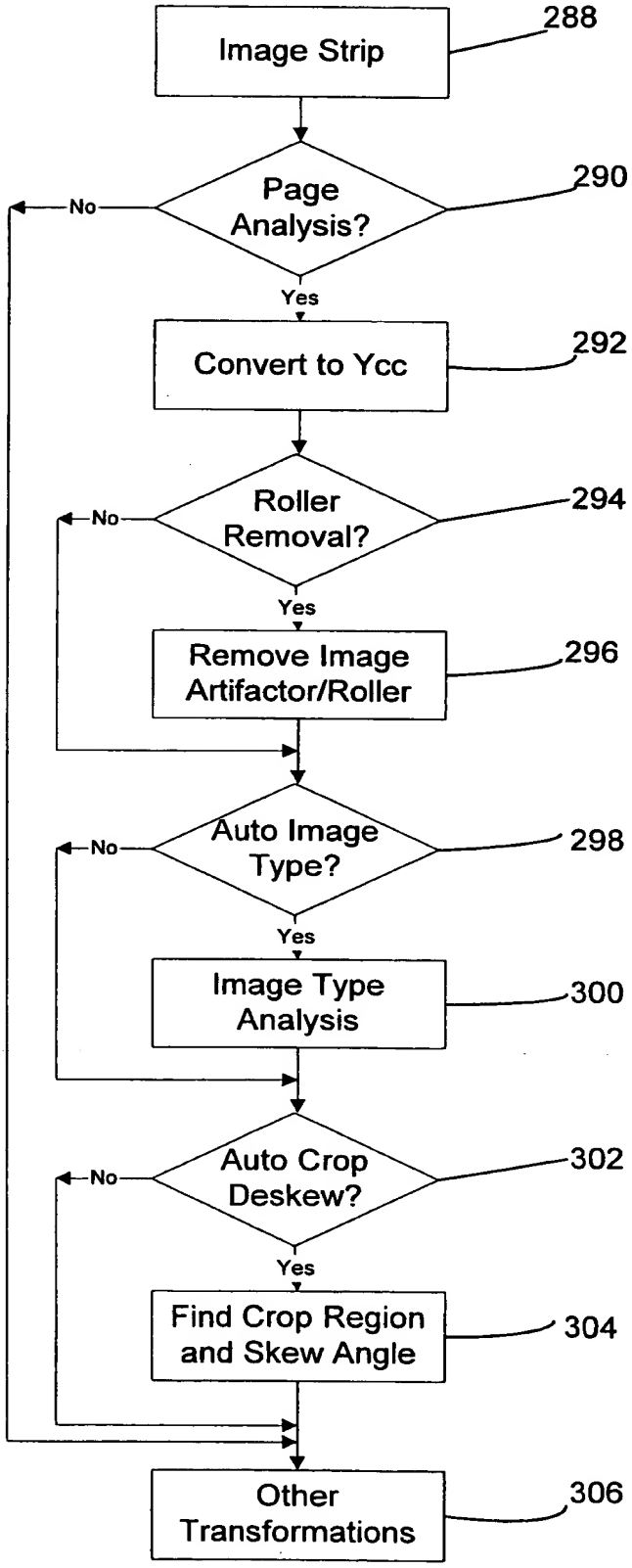


Image Strip
288
Page Analysis?
290
No
Yes
Convert to Ycc
292
Roller Removal?
294
No
Yes
Remove Image Artifactor/Roller
296
Auto Image Type?
298
No
Yes
Image Type Analysis
300
Auto Crop Deskew?
302
No
Yes
Find Crop Region and Skew Angle
304
Other Transformations
306

FIG. 28

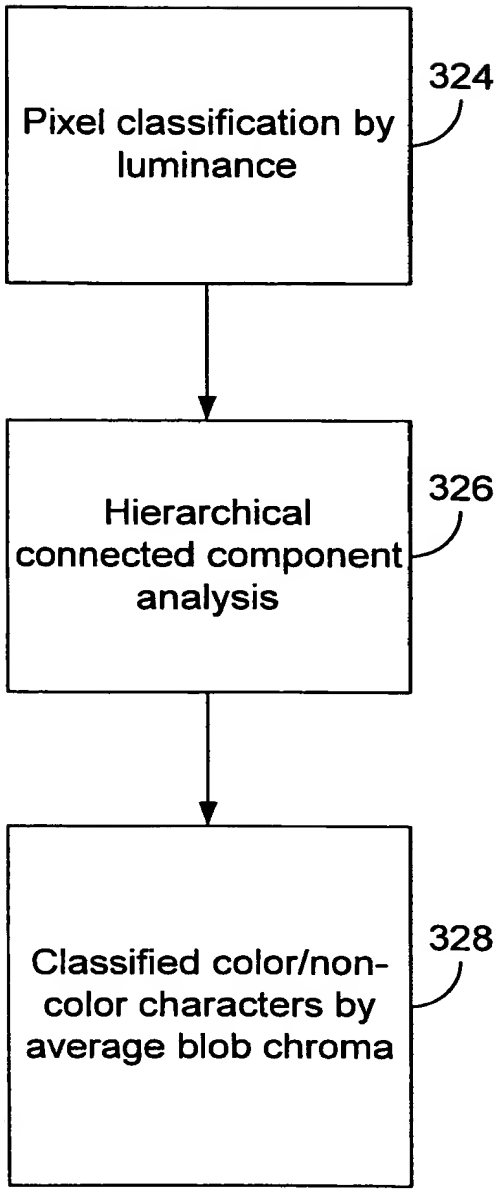
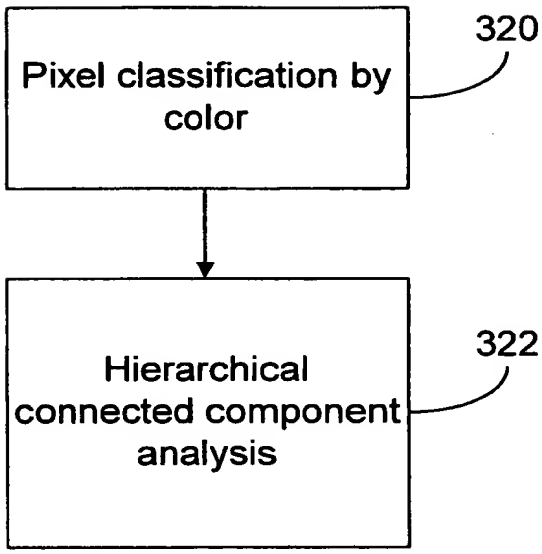

Pixel classification by luminance
324
Hierarchical connected component analysis
326
Classified color/non-color characters by average blob chroma
328

FIG. 27


Pixel classification by color
320
Hierarchical connected component analysis
322